REMARKS

Overview of the Office Action

Claims 1 and 3-5 have been rejected under 35 U.S.C. §102(b) as anticipated by "The Formation of Crystalline defects..." by Kawaguchi et al. ("Kawaguchi").

Claims 2 and 6-12 have been rejected under 35 U.S.C. §103(a) as unpatentable over Kawaguchi in view of Applicants' Admitted Prior Art ("AAPA").

Claims 13-17 and 34 have been rejected under 35 U.S.C. §103(a) as unpatentable over Kawaguchi in view of "InGaN-Based Blue Light Emitting Diodes..." by Mukai ("Mukai").

Claims 1, 4, 5, 13-17, and 34 have been rejected under 35 U.S.C. §103(a) as unpatentable over "Pit formation in GaInN quantum wells" by Chen et al. ("Chen") in view of U.S. Patent No. 6,555,846 ("Watanabe").

Claims 2 and 6-12 have been rejected under 35 U.S.C. §103(a) as unpatentable over Chen in view of Watanabe, and further in view of AAPA.

Status of the claims

Claims 1 and 2 have been amended.

Claims 3 and 18-33 have previously been canceled.

Claim 35 has been newly added.

Claims 1-2, 4-17, and 34-35 remain pending.

Interview of February 22, 2008

Applicants wish to thank the Examiner for the telephone interview held on February 22, 2008.

During the interview, the merits of Kawaguchi anticipating Applicants' invention were discussed. The Examiner maintained that Kawaguchi teaches "wherein said regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer", as recited in Applicants' claim 1. In particular, the Examiner asserted that Applicants' claim 1 does not indicate that the structure produced by the recited method is the final or completed structure, and is therefore anticipated by the structure of Kawaguchi that occurs during the growth of the "Region II" InGaN layer. Further, with respect to Fig. 4B of Kawaguchi, the Examiner asserted that "Region I" is shown in two dimensions and "Region II" is shown in three dimension.

No agreement was reached. Applicants' response to the Examiner's assertions are contained in the discussion below.

Rejection of claims 1 and 3-5 under 35 U.S.C. §102(b)

The Office Action states that Kawaguchi teaches all of Applicants' recited elements.

Independent claim 1 has been amended to recite a method for fabricating a light-emitting device that includes forming at least one compound semiconductor layer based on gallium nitride and being an active layer or a part of an active layer sequence, the at least one compound semiconductor layer being a light-emitting layer. The method further includes setting growth parameters used during production of the compound semiconductor layer such that, at least in some cases in a vicinity of dislocations in the compound semiconductor layer, regions are

produced in the compound semiconductor layer having a lower thickness than remaining regions of the compound semiconductor layer, wherein the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device. Support for the amendment to claim 1 can be found in Applicants' original claim 2 and paragraph [0011] of Applicants' specification. More specifically, paragraph [0011] states that the device of the invention is distinguished by the fact that the thickness of the light emitting layer in the vicinity of the dislocations is less than the remaining regions. Since the light emitting layer with the dislocations is described as part of the device, the layer discussed in the specification and the claims is part of the final structure of the light emitting device.

Kawaguchi fails to teach or suggest "wherein the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device" as recited in Applicants' amended independent claim 1.

The Examiner cites Figs. 2b, 4a, and 4b of Kawaguchi as allegedly teaching that the regions are formed with lower thickness less than half as thick as the remaining regions of the compound semiconductor layer. Applicants submit that Kawaguchi has been misinterpreted.

According to Kawaguchi, at the initial growth state the InGaN layer was 100 nm and the depth of the pits was 30 nm (see Fig. 1a and page 25, col. 1, "Results and discussion" of Kawaguchi). Thus, the remaining region (i.e., the portion under the pit) is 70 nm (i.e., 100-30), which is greater than half the thickness of InGaN layer. When the layer thickness was increased to 2000 nm, the height of the top of the pyramid from the valley (of the pit) was 300 nm (see Fig. 1b and the last two lines of page 25, col. 1 to the end of the first paragraph of col. 2 of "Results

and discussion" Kawaguchi). Thus, the remaining region is 1700 nm (i.e., 2000-300), which again is greater than half the thickness of InGaN layer.

Fig. 2c of Kawaguchi simply shows that the pits are 500 nm after the next growth stage (see page 27, col. 1, second paragraph of Kawaguchi).

Further, according to Kawaguchi, in the next growth stage, a second InGaN is grown on the first InGaN layer. Fig. 2c of Kawaguchi simply shows that the pits are 500 nm after the next growth stage (see page 27, col. 1, second paragraph of Kawaguchi). Thus, an additional InGaN is grown on the already 2000 nm thick InGaN layer. Kawaguchi does not indicated how much InGaN is grown in the next growth stage. However, given the thickness of the InGaN layer of from the initial growth stage (i.e., 2000 nm), the remaining region is at least 2000 nm – 500 nm (pit depth), or 1500 nm, which is more than half of the remaining region of InGaN layer.

Nothing in Kawaguchi indicates that the remaining region of the InGaN layer is ever less than half as thick as the whole InGaN layer, either in a transitional growth stage or in the completed structure. However, Applicants' claim 1 has nevertheless been amended to clarify that the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device.

Fig. 4a of Kawaguchi shows a first InGaN layer (Region I) grown on a GaN layer. No thickness of the InGaN layer is provided and no depth of the pits is provided. Fig. 4b, which is a two-dimensional drawing, shows a second InGaN layer (Region II) grown on top of Region I. No thickness of the InGaN layer is provided and no depth of the pits is provided.

The Examiner asserts that Region II is only grown on the flat surfaces of Region I, the thickness of the InGaN is the combination of Region I and Region II, the pits grow bigger, and the remaining region thickness remains the same. However, the Examiner's interpretation

makes no sense. Fig. 4b shows that when Region II is grown on top of Region I, the InGaN of Region II fills in the pits of Region I, and new pits are formed on the top of Region II. Further, Applicants' cannot understand how the Examiner can interpret Fig. 4b as a three dimensional figure. If Fig. 4b of Kawaguchi was a three dimensional drawing, Region I would be a side surface and Region II would be a top surface of the same layer. However, this is not the case as Kawaguchi clearly describes Fig. 4a as a thin layer and Fig. 4b as a thick layer, and that Region I is a first low defect density layer and Region II is a second high defect density layer. Fig. 3 of Kawaguchi also clearly shows that Region II, when grown on top of Region I fills in the pits of Region I, and new pits are formed on top of Region II.

Moreover, Kawaguchi provides no statement or suggestion, and neither is there any basis for concluding that Fig. 4b is drawn to scale. Kawaguchi states only that Figs. 4a and 4b are schematic diagrams of the heterostructure which is previously described in reference to Fig. 3. Therefore, there is no way to determine from Fig. 4b of Kawaguchi the relative thickness of the regions in the vicinity of dislocations. All the dimensions that Kawaguchi does provide (and discussed in detail above) for the InGaN thickness and pit depth clearly show that the remaining region never comes close to being less than half the thickness of the InGaN layer. Thus, there is no basis provided in Kawaguchi for interpreting Figs. 4a and 4b any differently.

Thus, Kawaguchi fails to teach or suggest "wherein the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device" as recited in Applicants' amended independent claim 1.

In contrast to Kawaguchi, Applicants' amended independent claim 1 expressly recites that "said regions with the lower thickness are formed to be less than half as thick as the

remaining regions of the compound semiconductor layer in the final structure of the light-emitting device".

In view of the foregoing, Applicants submit that Kawaguchi fails to teach or suggest the subject matter recited in Applicants' amended independent claim 1. Accordingly, claim 1 is deemed to be patentable over Kawaguchi under 35 U.S.C. §102(b).

Dependent claims

Claims 3-5, which depend from independent claim 1, incorporate all of the limitations of independent claim 1 and are, therefore, deemed to be patentably distinct over Kawaguchi for at least those reasons discussed above with respect to independent claim 1.

Rejection of claims 2 and 6-12 under 35 U.S.C. §103(a)

The Office Action further states that the combination of Kawaguchi and the AAPA teaches all of Applicants' recited elements.

Kawaguchi has been previously discussed and does not teach or suggest the invention recited in Applicants' independent claim 1.

Because Kawaguchi does not teach or suggest the subject matter recited in amended independent claim 1, and because the AAPA does not teach or suggest any elements of independent claim 1 that Kawaguchi is missing, the addition of the AAPA to the reference combination fails to adversely affect the non-obviousness of that claim.

Claims 2 and 6-12, which depend from independent claim 1, incorporate all of the limitations of independent claim 1 and are, therefore, deemed to be patentably distinct over

Kawaguchi and the AAPA for at least those reasons discussed above with respect to independent claim 1.

Rejection of claims 13-17 and 34 under 35 U.S.C. §103(a)

The Office Action further states that the combination of Kawaguchi and Mukai teaches all of Applicants' recited elements.

Kawaguchi has been previously discussed and does not teach or suggest the invention recited in Applicants' independent claim 1.

Because Kawaguchi does not teach or suggest the subject matter recited in amended independent claim 1, and because Mukai does not teach or suggest any elements of independent claim 1 that Kawaguchi is missing, the addition of Mukai to the reference combination fails to adversely affect the non-obviousness of that claim.

Claims 13-17 and 34, which depend from independent claim 1, incorporate all of the limitations of independent claim 1 and are, therefore, deemed to be patentably distinct over Kawaguchi and Mukai for at least those reasons discussed above with respect to independent claim 1.

Rejection of claims 1, 4, 5, 13-17, and 34 under 35 U.S.C. §103(a)

The Office Action states that the combination of Chen and Watanabe teaches all of Applicants' recited elements.

As previously mentioned, independent claim 1 has been amended to recite a method for fabricating a light-emitting device that includes forming at least one compound semiconductor layer based on gallium nitride and being an active layer or a part of an active layer sequence, the

at least one compound semiconductor layer being a light-emitting layer. The method further includes setting growth parameters used during production of the compound semiconductor layer such that, at least in some cases in a vicinity of dislocations in the compound semiconductor layer, regions are produced in the compound semiconductor layer having a lower thickness than remaining regions of the compound semiconductor layer, wherein the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device.

Chen and Watanabe, whether taken alone or in combination, fail to teach or suggest method for fabricating a light-emitting device that includes "forming at least one compound semiconductor layer based on gallium nitride and being an active layer or a part of an active layer sequence, the at least one compound semiconductor layer being a light-emitting layer", and "wherein said regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer in the final structure of the light-emitting device", as recited in Applicants' claim 1.

Chen is concerned with pit formation in InGaN quantum wells, where the pits were determined to have a hexahedron morphology with six sidewall planes and dislocations connected to the pit vertices.

The Examiner concedes that Chen fails to teach or suggest "wherein said regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer", as recited in Applicants' claim 1.

Further, Chen does not disclose a light-emitting layer in Fig. 1 or the description. Chen mentions an LED only in the introduction. The disclosure of Chen, however, is entirely concerned with a general study of the growth of InGaN quantum wells. The layer stack shown in

Fig. 1 of Chen cannot be a light-emitting device because the quantum wells are capped with an undoped 300 nm thick AlGaN layer. Therefore, it would not be possible to apply a current to the layer stack disclosed by Chen.

Watanabe fails to teach or suggest what Chen lacks because (1) Watanabe does not teach that the layer with pits is a light emitting layer, and (2) Watanabe teaches that pits in the first layer are to be filled and flattened, i.e., minimized.

The Examiner cites Figs. 2 and 3, and col. 3, line 29 to col. 6, and col. 5, lines 24-65 of Watanabe as teaching regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor layer.

Watanabe discloses a group III nitride semiconductor device, which has a reduced number of threading dislocations adversely affecting characteristics of the group III nitride semiconductor device. Watanabe also discloses a method for manufacturing group III nitride semiconductor devices that control pit formation in a GaN layer on a sapphire substrate. (see abstract of Watanabe).

The device of Watanabe includes a multilayer structure in which nitride semiconductor single-crystal layers are formed on a sapphire substrate (1). A low temperature buffer layer (2) of AlN or GaN is formed on the sapphire substrate (1) of Watanabe. A non-doped GaN crystal layer (3) is formed on the low-temperature buffer layer (2) as a first GaN layer. The non-doped GaN crystal layer (3) takes on an island-like structure without any dopant. A second GaN layer (4) containing a dopant is formed on the first GaN layer. The second GaN layer (4) is deposited while filling pyramidal surface voids in the first GaN layer (3) and flattening the surface of the GaN layer (3). A non-doped GaN crystal film (5) is formed on the second GaN layer (4) as a third GaN layer. A crystal layer (6) is formed on the GaN crystal film (5). Furthermore, an n-

type cladding layer (7), an active layer (8), a p-type cladding (9), and a p-type contact layer (10) are formed in the stated order on the layer (6). Then, a p-type electrode (11) and an n-type electrode (12) are formed on the p-type contact layer (10) and the fourth crystal layer (6), respectively (see col. 3, lines 28-51 of Watanabe).

Figs. 2 and 3 of Watanabe show pits formed in a GaN layer (3). From Figs. 2 and 3 of Watanabe, the some of the regions below the pits appear to be less than half the thick as the GaN layer (3). However, nowhere in the text of Watanabe is it explicitly stated that the region below the pits are less than half the thick as the GaN layer (3). The cited passages of Watanabe only teach that pyramid surface voids are formed in the GaN layer (3), and that second GaN layer (4) fills the pyramid surface voids formed in the GaN layer (3).

Watanabe does not, however, teach or suggest that the regions with the lower thickness and formed to be less than half as thick as the remaining regions of the compound semiconductor layer are formed in at least one compound semiconductor layer that is a light-emitting layer, as recited in Applicants' amended claim 1.

As shown in Figs. 2 and 3 of Watanabe, the active layer (8) does not include any such regions of lower thickness. Nor does Watanabe teach or suggest that such regions of lower thickness are, or could be, formed in the active layer (8). In fact, Watanabe does not disclose that the active layer (8) has any variations in its thickness. Instead, the active layer (8) of Watanabe is flat and has a uniform thickness.

In contrast to Watanabe, Applicants' recited regions of lower thickness are formed in the compound semiconductor layer, which is a light-emitting layer. According to Applicants' invention, the regions of lower thickness are formed to produce shielding energy barriers, which suppress diffusion of charge carriers toward the dislocations and prevent non-radiating

recombination of electron-hole pairs at the dislocations (see paragraph [0012] of Applicants' specification).

With respect to the pits, Watanabe is only concerned with controlling pit formation formed in a GaN layer that is formed on a sapphire substrate. Watanabe is not at all concerned with forming pits in a light-emitting layer to purposefully produce shielding energy barriers. Moreover, Watanabe discloses that the pits formed in the GaN layer should be filled and flattened by subsequent layers (see col. 2, lines 40-44 and 56-60 of Watanabe).

Thus, it is clear that neither Chen nor Watanabe teach or suggest, or provide any motivation for, forming a light emitting layer with a non-uniform thickness, where regions with the lower thickness are formed to be less than half as thick as the remaining regions of the light emitting layer.

In contrast, Applicants' recited invention purposely involves setting growth parameters used during production of the compound semiconductor layer such that, in a vicinity of dislocations in the compound semiconductor light-emitting layer, regions are produced in the compound semiconductor light-emitting layer having a lower thickness than remaining regions of the compound semiconductor light-emitting layer, wherein the regions with the lower thickness are formed to be less than half as thick as the remaining regions of the compound semiconductor light-emitting layer. Such a configuration or purpose is not taught or suggested by Chen, Watanabe, or the combination thereof.

In view of the foregoing, Applicants submit that Chen and Watanabe fail to teach or suggest the subject matter recited in Applicants' amended independent claim 1. Accordingly, claim 1 is deemed to be patentable over Chen and Watanabe under 35 U.S.C. §103(a).

Dependent claims

Claims 4, 5, 13-17, and 34, which depend from independent claim 1, incorporate all of the limitations of independent claim 1 and are, therefore, deemed to be patentably distinct over Chen and Watanabe for at least those reasons discussed above with respect to independent claim 1.

Rejection of claims 2 and 6-12 under 35 U.S.C. §103(a)

The Office Action further states that the combination of Chen, Watanabe, and the AAPA teaches all of Applicants' recited elements.

Chen and Watanabe have been previously discussed and do not teach or suggest the invention recited in Applicants' independent claim 1.

Because Chen and Watanabe does not teach or suggest the subject matter recited in amended independent claim 1, and because the AAPA does not teach or suggest any elements of independent claim 1 that Chen and Watanabe are missing, the addition of the AAPA to the reference combination fails to adversely affect the non-obviousness of that claim.

Claims 2 and 6-12, which depend from independent claim 1, incorporate all of the limitations of independent claim 1 and are, therefore, deemed to be patentably distinct over Chen, Watanabe, and the AAPA for at least those reasons discussed above with respect to independent claim 1.

Newly added claim 35

Claim 35 has been newly added. Support for claim 35 can be found in Applicants' original claim 1 and in paragraph [0012] of Applicants' specification.

Claim 35 recites limitations similar to independent claim 1 and is, therefore, deemed to be patentably distinct over the cited references for at least those reasons discussed above with respect to independent claim 1.

Additionally, claim 35 recites "wherein said regions with the lower thickness are formed to produce shielding energy barriers, which suppress diffusion of charge carriers toward the dislocations and prevent non-radiating recombination of electron-hole pairs at the dislocations", which is also not taught or suggested by any of the cited references.

Conclusion

In view of the foregoing, reconsideration and withdrawal of all rejections, and allowance of all pending claims, are respectfully solicited.

Should the Examiner have any comments, questions, suggestions, or objections, the Examiner is respectfully requested to telephone the undersigned in order to facilitate reaching a resolution of any outstanding issues.

Respectfully submitted,

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